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The impact of portable computers on classroom learning environments

Current issues and limitations in using the Internet for teaching and learning

Opening school doors to the real world: A review of literature on computer mediated communication and its role on the creation of constructivist learning environments

Implementing new generation instructional information management systems: A Western Australian example

Cumulative Index - Volume 1 to Volume 12
Michelle Williams President ACCE

Michelle has a long history of CEG involvement. She has been a member of Queensland Society for Information Technology in Education (QSITE) since 1984, holding management committee positions since 1988, including president of QSITE from February 1993 until March 1998. She has been a member of the ACCE executive since 1995 and was appointed president of ACCE in September 1997. She has been speaking at and attending CEG conferences in Queensland since 1993, and has more recently been a keynote speaker at CEG conferences in Victoria, Western Australia and Tasmania. She has attended almost every National conference since 1984 and presented papers at each ACEC conference since 1993. She has convened a number of state conferences as well as the National Computer Studies Teachers Conference in 1997.

In her day job, Michelle is a lecturer in the School of Mathematics, Science and Technology Education at Queensland University of Technology. Previously she held a number of teaching positions interspersed with a period as a regional computer education advisor and a state computer education coordinator. At QUT she is a member of the Research in Information Technology Education group (RITE) which hosts oz-TeacherNet, a national project which provides telecommunications-centred curriculum projects and national and state online communities for teachers.

Her passion is centred on building open learning strategies for teacher professional development within and alongside formal courses of study and in drawing attention to computer studies as a discipline in Australian Schools. She speaks and writes about the importance of giving teachers access to machines and about the importance of connecting teachers with each other, so they have some experiential base upon which to interpret curriculum in new ways and lead different professional lives. The favorite part of her work, is teaching, where she has opportunity to help great people become excellent teachers in primary and secondary schools.

At home, Michelle is an avid restorer of Australian bush and is currently involved in her own and some community projects to restore of the destroyed Queensland landscapes. Living in Ipswich, Queensland, she telecommutes as often as practical while enjoying her bush-setting. Her current project is to conquer the skies in a real plane, albeit somewhat unsuccessfully. She is better at being a devoted aunt to her favorite niece Brooke in all the leftover spare time.
This issue focuses on educational research. Research is as varied as the education systems upon which it focuses. There is large scale quantitative research, small scale qualitative studies such as ethnographies and in classroom action research. Indeed, all education practitioners are potential researchers as they try new teaching strategies, modify behaviours and basically work out what works and what does not. The conducting of research is of little consequence unless the results are shared.

I write this a month before the Australian Computers in Education Conference in Adelaide, an event that brings together some of the best educators and researchers from around Australasia. Events such as this are more than just opportunities to hear about what is new, they are times to network, share ideas and overcome the insular nature of many of our education systems. This parochial approach to education seems to be a function of the size of our country, the political segmentation into States and a multitude of education systems all trying to reinvent the wheel. We need to break down these barriers to effective communication and share our knowledge for the benefit of all Australians. ACCE, the journal, the national conference and the Internet can help us to do just that.

The World Wide Web is often hailed as being the educational equivalent to the second coming and it is easy to forget that it is just a technology. It is the content and teaching strategies that the World Wide Web allows us to share that are consequential to education. Another technology that facilitates sharing is the internet mailing list or List-serv. In Internet folklore there is a saying that “on the Internet no one knows that you are a dog”, One can paraphrase this to be “on a list-serv no-one cares if you are from Halls Creek or Parramatta, a university lecturer or kindergarten teacher, an expert or a novice.” You are all part of an on-line community of fellow educators supporting and helping each other.

This issue contains a cumulative index of the articles from the first 12 volumes of AEC, bar Vol 1. no. 2 and Vol. 2 no. 2 which are missing from our collection, (if you have them please send me an email or give me a call). The second issue from each year will in future contain an index for that year on its back page. Information such as this will provide a ready reference for any research previously done in your teaching area and/or fields of interests.

The second issue for 1998 will contain reports on how each state is integrating computers into their education systems.
Welcome to Australian Educational Computing for 1998. I expect that this issue of the journal will follow the trend of its predecessors, contributing to the recorded history of educational computing in this country. This journal volume contains an index of the key articles in AEC's 11 year history and reminds me of how the journal and the national conference proceedings record the best practice in computer education nationally. It is a history to be proud of. Since becoming president of Australian Council for Computers in Education (ACCE), I have become aware of how little members of Computer Education Groups (CEGs), know about ACCE history and purpose. I am hoping my first column can not only define ACCE's place in people's hearts, but also record its place in the historical archive we have been proudly building.

The Australian Council for Computers in Education was formed to give national status to computer education and to build a significant national professional association to complement the membership status within CEGs. Various boards of ACCE have earned a very high status in a range of forums. This was demonstrated recently, by being invited to help other national associations understand the importance of information and communications technologies for professional association work and for supporting teacher communities within the DEETYA-funded Natcom project. As you would expect of a national association, ACCE also provides input to national issues where possible and builds national frameworks and policies for advice to all systems and educational groups. I was not aware of the extent of ACCE influence until I became a member of the Board. Now in the president's role I am reminded of it so often and hope though my writing and actions, that I can help members understand the importance and authority of our national voice.

Although the political position of ACCE is sufficient to cement its place in our computer education group structure, the council's main roles are to support the work of state computer education groups and to provide national services for state members. The most visible services which states' members see are the National Journal and a biannual Australian Computers in Education Conference, ACEC. Often specialist national conferences are hosted in the alternative year. Computer education groups gain opportunity to host events or manage the journal. Importantly, they can also use the ACCE structure to seek resources, gain professional development about managing the computer education group and directly take advantage of the expertise within the association's executives to support their work, resolve issues and gain access to new ideas. This happens because CEG executives share their expertise willingly with their colleagues in a spirit you would expect from a collaborative council of peer groups. This is demonstrated clearly within ACCE efforts to help the Northern Territory Computer Education group redevelop and by providing consultancy to the New Zealand national and regional computer education groups. ACCE achieves a great deal within the resources it has available.

It is important for members of CEGs to understand the membership, groups and affiliations structure of ACCE and particularly to understand the difference between the Council itself and the Board. ACCE contains 9 members: each state computer education group and territory plus the Australian Computer Society (ACS). ACCE itself, is a member of the Technology Federation of Australia (TEFA), the National Education Forum (NEF) and the National Joint Council of Teacher Professional Associations (NJCTPA). ACCE is also an Affiliate of the International Society for Technology in Education (ISTE). The Board contains 10 representative positions: one from each state and territory, a representative of the Australian Computer Society and a representative of the Technology Federation of Australia. The bottom line of
course is that 10 volunteer people have done amazingly well to achieve so much at a national scale. The membership story is further complicated by MACCE status that is afforded to members of Computer Education Groups (MACCE: Membership of the Australian Council for Computers in Education). In 1998 the Board is developing additional levels of MACCE membership which will add status to membership at state level and provide leading educators with recognition of their contributions to this professional community.

ACCE has a number of projects for 1998 that add to its usual business. Firstly, ACCE has been involved in implementing the NATCOM project, a project which helps National Key Learning Area Professional Associations learn how to take advantage of the connectivity that is becoming increasingly important to educators in all spheres of our business. At first this project helped associations deal with the issues familiar to CEGs who pioneered online environments and built online communities like EChalk and QSITE-community, rather than having built look-up libraries. This approach has drawn national attention and helped groups like DEETYA and Education.au understand the new professional development spaces we are using. This project is now maturing and in 1999, a number of national associations will be hosting telecommunications projects that model new pedagogies and new curriculum interpretations using naturally, the models and experiences which we can draw on within our communities of expertise. There is little doubt that this work is directly adding quality to the current projects of joint councils nationally and in states and also influencing how other groups, like the national principals’ associations, build online communities and mainstream online services.

Secondly, ACCE is building a range of tools that State CEG’s might use in helping draw people together in associations. The ACCE web site will be directly aimed at collecting tools for CEG groups to use. For example, CEGs will soon be provided with the coding to build an online directory of expertise and provided with a structure to build a weblography of articles produced in each CEG journal as well as AEC. As opportunities arise, ACCE will promote sharing of online tools between CEGs and undertake development projects as required.

Thirdly, ACCE is investigating the implications of teacher learning technology competencies within states. Helping reduce the duplication of effort is sufficient reason for this project. However, helping define standards and then building strategies for helping teachers attain and demonstrate competencies is directly related to CEG programs in the immediate future. ACCE has undertaken to collate data, collect opinions and produce some working papers and resources, to support CEGs as they cope with these new pressures on our members. This debate will be aired at the National conference and in our various online communities.

Lastly, professional development for CEG management teams is part of the new role of ACCE. This process begins at the 1998 conference in Adelaide and will continue throughout 1998.

Financial concerns are always at the heart of questions from CEGs. ACCE has three main sources of funding. Firstly, each CEG provides a capitation fee to the national body at the rate of $8.00 per capita. Funds also derive from 4% of registrations from profitable ACEC conferences. More recently, major projects like the Natcom project have enabled ACCE to economise on meeting costs and thus save expenditure. ACCE has a very small operating margin and runs its account very frugally. The financial statement is presented at each ACCE AGM and copies are sent to each CEG and Board representative. The financial management of ACCE is extremely open.

The main two items of expenditure for ACCE are the national journal and 2 Board meetings per year. There are also some annual projects which have their own budget. One of these is the $4000 conference seeding fund which is housed by the CEG hosting the current conference. Another is the payment for the ACCE Educator of the Year award. More recently an annual amount for web development and maintenance has become a part of the core business of the Council. Other expenditure maintains ACCE Registration and the securities commission, membership of other national groups and affiliate bodies and recovers the general housekeeping expenditure. I think you will agree that the $8 per member is well used and complemented by occasional funds from other projects.

In closing this column, I want to draw attention to work of two CEGs. ECAWA is currently hosting this National Journal. Their volunteer work is appreciated by the Board members and I am confident you recognise the contribution of the journal to our history and to the job it undertakes in shaping computer education in the country. It is the only internationally refereed journal in computer education in Australia and an important contribution to international literature. It is wonderful to have this vehicle to showcase Australian teachers and researchers. Thanks to Jeremy Pagram, Paul Newhouse and the editorial team from ECAWA. I would also like to recognise the work of CEGSA, who are hosting ACEC 98. Their conference group has modeled expert conference management and like their predecessors, CEGSA will have the opportunity to consult with the next host CEG. The development of the ACCE Conference policies and procedures documents has emerged from this collaboration and I am confident our documentation will continue to improve. The results show in a great conference. Thanks Ralph Leonard and the CEGSA team.

Until next journal, I wish you well and look forward to meeting with as many management teams and CEG members as possible. In the meantime I welcome your comments, suggestions and ideas. Please email me whenever you need.
The impact of portable computers on classroom learning environments

The impact of portable computers on classroom learning environments

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There are convincing arguments for the integration of computer applications into school programmes to support the learning of students. After more than 30 years of increasing investment in educational computing, researchers are concerned that there has been very little impact on the experiences of students in schools. In the 1990s, a significant development in computer technology has been the emergence of low-cost, high-powered portable computers which some schools have introduced into classrooms. It is not clear what the impact of this development might be.

A three year study was conducted at a school to address issues concerning the impacts of student-owned portable computers on students, teachers, the curriculum, and the classroom learning environment. In each year of the study, data were collected about students, teachers and a selection of classrooms using observations of lessons, interviews, questionnaires, and administrative data and documents obtained from the school’s administration.

Among other things the study found that, apart from isolated teacher-class combinations, there was very little change at the classroom level which could be attributed to the presence of the computers. Very few teachers implemented substantial computer use and many of those who had, supported only a very limited role for the computers. This paper argues that the lack of use of the computers is largely related to the teacher’s preferred pedagogy, their lack of experience and knowledge in using computers in the classroom, and a lack of time to experiment with computer applications. Increasingly, the teachers who chose to facilitate the use of the computers did so to support predominately student-centred learning environments. These findings have important implications for educational policy makers, administrators and teachers and enable a clearer understanding of the factors which determine the successful implementation of computers into school programmes to support student learning.

Introduction

Educators have increasingly claimed that for the potential of computers in education to be realised critical changes will be required in schools and classroom learning environments. However, the finding of Plomp and Pelgrum’s (1992) international comparative study was that there was little evidence in any of the participating countries of real changes in the structure of schools or classrooms as a result of new technologies. Will these changes come about due to the avalanche of computers into schools, particularly through schemes to provide one computer per student or must these changes occur before embarking on such schemes? The popular press often portrays the belief that the technology will instigate the changes. The following statement by Schumpeter (1993) is typical of this, “A Melbourne school is pushing the boundaries of educational development in a laptop experiment that could make traditional teaching methods redundant” (p. 1).

Now that access to computers in classrooms is more readily available, even to the extent of one per student, why are so few teachers realising the potential? If computers were extensively used by students to support school-based learning, it has been suggested that this would necessarily change the role of the teacher and the nature of the classroom learning environment (Reeves, 1992; Rieber & Welliver, 1989; Schank & Cleary, 1995). Further, it has been suggested that such an extensive use of computers may reform the structure of schooling and the curriculum itself with a greater focus on student-centred learning, across curriculum activities and more flexible school structures. That is, widespread use of computers in schools may either require a restructuring of schools or could support the restructuring of schools.

While it is relatively safe to contend that most students in the future will have some form of portable computer processing in much the same way as most secondary students now have calculators, given the historically robust nature of school-based education it is difficult to predict in practice what impact this will have on schooling and the curriculum. Longitudinal research into the use of
portable computers by students needs to be conducted at many school sites before any reasonable predictions can be made about their likely impact. Marcinkiewicz (1994) suggests that “there is little research evidence for the effectiveness of educational technology and that which exists provides little direction for informing teachers about how they can use the technology most appropriately” (p. 221). Research is needed to guide school systems, school leaders, teachers, parents and students in the application of such a resource to school-based learning. This paper reports on a study which set out to address this need by considering the use of student-owned portable computers to support the lower secondary school programme at one school over a three year period.

Method

The researcher was invited by the Principal of the school to conduct an independent evaluation of the implementation of an initiative, eventually known as the Portable Computer Programme (PCP), designed to encourage every student to have and use a portable computer to enhance their learning. As a result the researcher became immersed in the school community for a period of three years and collected a wide variety of data from students, teachers and the administrative records of the school. To investigate the impact of a computer-related innovation on classroom learning environments it was necessary that the study be both longitudinal and grounded in ethnographic research traditions.

The study used both qualitative (lesson observations, formal and informal interviews, and viewing documents and software) and quantitative (questionnaires, log sheets, administrative records) data collection strategies. The study relied more on the qualitative data sources for the majority of its findings. The quantitative data sources tended to be used to give contextual or background information or to corroborate findings based on the qualitative data.

Data were collected from over 60 teachers, 350 students (three cohorts labelled A, B and C as indicated in Table 1) and the observation of a large number of lessons (71 were analysed). These data were continually analysed to address an evolving series of focus questions and thereby provide evidence to support a developing and increasingly more comprehensive understanding of the impact of student-controlled, portable computers on students, teachers and the implementation of the curriculum in the classroom learning environment.

Findings

Only a few of the findings of this large study can be discussed in this paper. The study focused on teacher and student attributes and their perceptions related to computer use, classroom activities, classroom and home use of the computers. The study also considered practical issues in implementing the PCP and its overall impact on classroom learning environments. Classroom learning environments which incorporate computers were considered using the model in Figure 1 and therefore the findings are discussed in terms of elements of this model: the portable computer systems, the students, the curriculum, and the teachers. Although each finding may have been related to all of these elements, each tended to relate more strongly to one element or one set of relationships between the elements.

Most experts in the field of educational computing, such as Olson (1988), Rieber (1994) and Lynch (1990), would characterise computers as interactive and thus admit them a place within the relationship structures within the classroom. Carter (1990) goes so far as to claim that “new technologies construct a totally new environment” (p. 34). Therefore the model in Figure 1 depicts the relationship between particular elements, including the computers. Strictly speaking, the computer systems and non-interactive technology are part of

Table 1

<table>
<thead>
<tr>
<th>Cohort</th>
<th>N. of students</th>
<th>Level of schooling</th>
<th>Period of time</th>
<th>Model of Macintosh computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38</td>
<td>Year Seven</td>
<td>1993 Semester 1</td>
<td>Powerbook 100</td>
</tr>
<tr>
<td></td>
<td>98a</td>
<td>Year Eight</td>
<td>1994 All year</td>
<td>Duo 230</td>
</tr>
<tr>
<td>Bb</td>
<td>95</td>
<td>Year Eight</td>
<td>1993 Semester 2</td>
<td>Duo 210</td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>Year Ten</td>
<td>1995 All year</td>
<td>Duo 210</td>
</tr>
<tr>
<td>C</td>
<td>103</td>
<td>Year Eight</td>
<td>1995 Semester 2</td>
<td>Powerbook 150</td>
</tr>
</tbody>
</table>

a Students from Cohort A in Year Seven were joined by students from other primary schools.

b The study also collected data on a small number of students from this cohort in Semester 1 of 1994.
computers are used within this writing tools using the word processor in or MacGlobe(r). In computing classes, it would be needed. Many students itself was not an inhibiting factor for these applications, most students in terms of operation and portability, but separation. The elements of the traditional classroom learning environment needing to interact with both the hardware and software.

**Portable Computer Systems in Schools**

The Macintosh notebook-style computers appeared to be well matched to the needs of the students in terms of operation and portability, but not physical reliability. Although most models of computer used did not appear to be sufficiently robust, this in itself was not an inhibiting factor for either students nor teachers.

Students were inhibited in their use of the portable computers by some features such as the short battery life and their perceived heaviness, resulting in some students leaving their computer at home if they did not think it would be needed. Many students preferred to use the school’s desktop computers because they liked the colour screens, larger keyboards, access to the network and greater processing power and memory. Similar problems and high level of maintenance costs have been reported from other schools using portable computers (Lyall, 1997).

The computers were mainly used as writing tools using the word processor in Clarisworks(r) with occasional use of Artgrabber(r) to insert clip-art. Apart from these applications, most students in classes other than specialised computing classes, used the computers only for game playing and the very occasional subject specific application such as Math Master(r) or MacGlobe(r). In computing classes, students used a wider range of applications on the computers from databases and spreadsheets to Hypercard(r), where they often found that the amount of memory (RAM) was inadequate.

While the value of the computers to students and teachers can not be fully quantified, consideration should be given to their effect on productivity. It is not possible to measure exactly the costs or outputs associated with educational processes such as the use of a technology in a learning environment. However, a rough estimate of the quantitative productivity of the computers, considering the best possible scenario recorded during the study (Year Eight Cohort C), was 0-5 hours/§A or about $A2 per hour. On the face of it this seems a very reasonable cost for the powerful tool it placed in the hands of the students. However, this does not take into account qualitative issues concerning the type and value of the activities to which the computers were applied. The limited role and application to learning activities diminishes even the quantitative productivity value to the students of using the computers. On top of this, there would be costs associated with teacher training, provision of infrastructure, cost of technicians and other support personnel, and the opportunity costs to students and teachers (i.e. the other things they could have been doing).

**Students’ Skills and Attitudes**

In general, students preferred choice in the possession of a computer, expected them to be used regularly to replace the need for paper-based files, quickly developed a reasonable level of computer literacy and associated indepen-
computer and would prefer one or the other. Generally they didn’t like being forced to use their computers. Many would have liked either more classroom-based computers or some system of short term loan.

Clearly the school could be satisfied that the PCP had improved the computer literacy and attitudes of students and had not significantly disadvantaged or perturbed more than a handful of students. Most students who appeared to be at risk in this regard had, by the end of Year Eight, overcome their negative attitudes towards the PCP and computers and had increased their skill and knowledge to an adequate level to make significant use of the computers. The school’s computer support teacher and the computing classes played important roles in overcoming the problems of these students.

The Curriculum

The subject area in the curriculum was a major determinant of the amount of computer use and the breadth of applications used by students. Students were more likely to use the computers for classes associated with subjects such as English and social studies in which teachers required a substantial amount of document production. Both students and teachers perceived that the use of the computers for document production improved the quality, quantity and ease of production.

The computers were less likely to be used in classes with older, higher ability students than younger and/or lower ability students. This seemed to result from teachers’ perceptions of the requirements of preparing students for tertiary entrance examinations. The tertiary entrance examinations dominated the curriculum for most teachers and students, even in the lower secondary school. Both teachers and students were aware that tertiary entrance examinations preclude the use of computers and this, in turn, discouraged the use of the computers in class-work. It was perceived that students needed to practice handwritten work in all subject areas to be prepared for these examinations. While there was little that could be done about the examinations themselves, further investigation should be conducted on the perceived link between using computers within the curriculum over the five years of secondary schooling and the performance of students in the tertiary entrance examinations.

Teachers

In responding to the presence of the portable computers in a class, a teacher’s actions could be classified into three broad types: (1) actively facilitates the use of the computers (Active), (2) permits the use of the computers by those students choosing to do so (Passive), or (3) unconsciously or otherwise discourages the use of the computers (Negative). Most teachers typically responded in either Negative or Passive ways which limited the use of the computers. Only a few (about eight) usually responded in Active ways which is consistent with Becker’s (1994) finding that only 5% of computer-using teachers are exemplary. His definition of such teachers would classify them as responding in an Active manner.

Many teachers were interested in facilitating the use of the computers but were not sure how to go about doing so with their classes. They did not want to be forced to use them but rather felt that they needed more examples of computer use applied to their area of the curriculum. Others did not see the computers as relevant to either their curriculum or their preferred teaching strategies. While many indicated a good level of computer literacy, a lack of operational knowledge of computers was still perceived by many as inhibiting their ability to facilitate students’ use of the computers.

The computers were not perceived as a necessary or even critically useful technology by almost all teachers. While most teachers encountered obstacles to facilitating the use of the computers which, when removed, may change this perception, it is likely that for most of them there were no compelling reasons to implement computer applications.

An obstacle either cited or inferred by many teachers concerned a lack of knowledge of, and access to, appropriate software. Often teachers claimed that there was no good software in their area of the curriculum. While Rieber and Welliver (1989) criticised most instructional software for being hardware-centred, representing a technocentric approach to software design and failing to tap the facilitation of higher-order thinking skills, Hannafin and Savenye (1993) suggest that software is rapidly improving. Most teachers were not aware of a reasonable range of software whether of good or poor quality. Many expressed a need for relevant information about software, typically represented by a request for a person to become a sort of software clearinghouse.

Given that many researchers (e.g. Becker, 1994) are now claiming that teachers need up to five years of experience in using computers in their learning programmes, it is perhaps not surprising that, after three years, this study should find that most teachers at the school were supporting only minimal use of the computers.

Classroom Learning Environments

Because of the minimal and limited use of the computers in classrooms very few classrooms were observed in which the use of the computers made any sustained or major impact on the learning environment. Only those teachers who aimed to create classroom learning environments which promoted student-centred learning (refer to Brady (1985)) tended to regularly facilitate the use of the portable computers with their classes. Where teachers employed an instructivist pedagogy (refer to Reeves (1993)), students were either required to use computers for only the limited role of a writing machine or were rarely required to use the computers at all. Research is increasingly supporting the notion that if computers are to be of significant value in classrooms, their introduction must be accompanied by a shift towards more student-centred teaching strategies (Dwyer, Ringstaff, & Sandholtz, 1991; Fishman & Duffy, 1994; Hannafin & Savenye, 1993). In the present study, those few teachers making this transition.
appeared to find the computers to be a valuable tool in the process.

**Evaluating the Success of the PCP**

The PCP was perceived by teachers, students and the researcher to be implemented most successfully in Year Eight in the third year of the study. The computers were applied more often, by more Year Eight students, in more learning activities, across more of the curriculum in increasingly meaningful and appropriate ways. The PCP increasingly facilitated the development of a greater degree of confidence, skills, understandings and attitudes which are likely to enhance learning and be applied to future situations (e.g. workplaces). However, the PCP clearly was not successfully implemented for the oldest student cohort (B) involved in the PCP, who were in Year Ten in the third year of the study.

This study set out to consider the impact of portable computers on the learning environment offered to students at the school. It was assumed that the most important concern was the amount and variety of use of the computers by students and teachers. Clearly, after three years, the computers were not used widely enough nor consistently enough to warrant their pervasive presence. However, encouraging signs had emerged by the third year of the study in Year Eight that the computers could play an important role in classroom activities and learning programmes. Where this was demonstrated in the school, it was usually associated with more student-centred approaches to learning. The overall level of computer literacy of students and staff involved in the PCP steadily improved, although further improvement was still necessary.

Despite the increasing success of implementation, the computers were still not used at school by most students for a large amount of time, but were used by all students at home for a reasonable amount of time. The limited use of the computers at school by even relatively interested teachers is consistent with the findings of wider surveys reported by those such as Becker (1994) and Plomp and Pelgrum (1992). Becker (1994) quotes that in one survey of computer using teachers only 11% of English teachers had students using spell-checkers and only 1% of mathematics teachers regularly facilitated the use of spreadsheets.

The computers were mainly used for word processing by all students and they were viewed by most students as essential for preparing assignments. However, there was a common perception amongst the staff that the computers were non-essential and merely supplementary items in their classrooms. This was reflected in the types of tasks which they allocated to the computers, typically replacing writing and at a low cognitive level. Most teachers had difficulty adapting the use of the computers to their own personal teaching style and subject curriculum. Fundamentally, to be successful, more teachers needed to employ student-centred approaches to learning more often in their learning programmes.

**Implications for Policy and Practice**

The findings of the study have a number of implications for educational policy and practice at both the school and system levels. Educational policy makers are currently concerned with what form of computer access should be implemented in schools to support learning. These deliberations include a consideration of what hardware and software is required and what level of standardisation is required. Questions also arise about the level and type of support needed by schools, teachers and students. The portable computer alternative is attractive to schools and education systems from both an educational and promotional point of view. These issues are considered in terms of a series of questions.

**Should Schools and Education Systems Implement Portable Computer Programmes?**

This study found that a programme such as the PCP could be successful but, without significant changes to the traditional curriculum and structures of schooling, this would be difficult to achieve. Also, without a transformation of the pedagogical philosophies of the teachers involved, it would have little impact on teaching and learning. In line with common international wisdom (e.g. Rieber & Welliver, 1989), policy makers should start by considering educational aims and instructional problems before considering technological solutions. Becker (1994) considers that if such a transformation is required then this will make it very difficult to extend the best practice use of computers in the classroom to a wider population.

In particular there is a need to remove or reduce the influence of paper and pen external examinations on the curriculum and organisation of schools. The organisation of schools needs to be dictated less by time and subject area boundaries and more by learning activities and the needs of students. There is a need to focus curriculum on processes rather than content, and there is a need to focus more on student-centred rather than instruction-centred strategies in learning programmes. Without changes in these fundamental components of the curriculum and schooling it is unlikely that the implementation of portable computers in schools will be cost effective.

**Should Students be Required to Standardise Hardware and/or Software?**

In the present study, students were not forced to use the recommended hardware and software, however almost all chose to use it because of the support offered by the school. It is not clear that this required strict standardisation because, if the school had chosen to out-source hardware maintenance, there would have been little reason for students to use the computers recommended. The students did not rely on teachers for operating instructions, they owned the licenses to almost all the software they used. It was probably more important for students to be able to personalise their hardware and software and choose configurations, provided they could connect to the school’s infrastructure. Students tended to indicate that they wanted choice...
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of whether to have a computer and which one to have. This would indicate that the acquisition of the computers by students should not be mandated but rather encouraged, and could include some system of short term loan.

While flexibility needs to be provided, it is clear that there is a minimum configuration of hardware and software required to allow effective use of portable computers in schools. Portable computers should include a backup storage device (floppy disk drive was adequate) and require enough RAM to concurrently open at least two of any of the software packages students are going to use regularly. Student computers should be supplemented with classroom-based computers with peripherals needed for some activities but not regularly, such as, large monitors, printers, scanners, better keyboards, graphic tablets, and CD-ROM drives. All classrooms need to be connected to the school’s network, or at least enough rooms so that interested teachers can be allocated such rooms. Teaching rooms, or at least a workable sample of rooms, need to have at least one colour screen and a CD-ROM drive available.

What Support do Students Require?

Students developed a reasonable degree of independence but still required and requested a more formal approach to learning how to use the computers. This will require the provision of specialist computing classes with highly competent computing teachers allocated to them. Perhaps one session per week or fortnight could be allocated so that it could be related to cross-curricular needs. Student access to computing staff and technicians is an important and necessary source of support which needs to be accommodated in some manner.

What Support do Teachers Require?

As with students, teachers should not be forced to use computers particularly where they are perceived to be of little value. Rather, teachers should continually be encouraged to make more use of the computers in class and use a greater range of software within their curriculum. This will involve the need to experiment with more student-centred, open learning strategies. The use of demonstration lessons or supported lessons would also help this process. Teachers need continuing access to professional development in the use of computers and applications to their own curriculum areas. It is commonly perceived, and was supported by this study, that the computer literacy of most teachers is still a major obstacle to greater application of computers to learning (McIntosh, 1997b).

Teachers need relevant information about software, with perhaps a person allocated to become a software clearing-house. In the provision of more software, the emphasis needs to be on increasing the range of software which can be targeted at the educational problems identified by teachers not simply increasing the quantity of software available. This type of information can be made available using Internet/Intranet technology. Therefore, in providing access to the Internet, the priority should be access for teachers before students.

This study found that the successful implementation of computers into learning programmes is fundamentally dependent on teacher beliefs, attitudes, perceptions and experiences. While all the key relationships within the classroom learning environment have some influence on, and are influenced by, computer implementation it is the relationship between the teacher and curriculum which is most important. This supports to some extent the argument of Miller and Olson (1994) that, “the computer environment as a consequence of teacher intention - its place in the scheme of the classroom is constructed by the teacher and the student” (p. 136). However, with the portable computers, the study found that only teachers who wanted to set up student-centred open learning environments tended to make use of the computers in the classroom (other teachers at best just required the computers to be used for written assignments). Perhaps other forms of implementation (e.g. laboratories, demonstration machines etc.) may be more likely to be used by teachers wanting to create more traditional learning environments.

Teachers should be encouraged to consider the computer as one of a range of technologies which they can call on to help them solve educational problems. With the development of ever more powerful portable computers and ever more extensive network systems, the range of problems which may have realistic computer-related solutions is expanding rapidly. Teachers should expect that computers will become an integral part of learning programmes and should gradually develop the skills, understandings and experiences required to exploit these opportunities. This also provides an opportunity to reflect on current practice and pedagogical beliefs with a view to realising preferred aims for learning programmes.

How Should Schools Aim to Support Learning by Implementing Computer Support?

A computer system is like a Swiss Army knife in that it is a flexible and varied tool which extends not only the physical (e.g. non-artists can create graphics) but also the intellectual capabilities of the user. In a sense Taylor (1980) was premature with his classification system of the three Ts, for there is really only one T, and that is Tool. His Tutor function is instructional-tool, while a Tutee function is a mind-tool (or cognitive-tool), what Taylor called Tool is a manipulative-tool (or psycho-motor tool). There are many types of computer-related tools which, just like other types of tools, must become “one” with the user to be used most effectively (Rowe, 1993). Therefore students need to become one with their computer systems which is facilitated by having their own software, both instruction and data files, but not necessarily their own hardware. They can then tailor their tools to their own specifications and liking.

The answer to questions concerning appropriate access to computer processing does not primarily
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The researcher, the school and wider education community with further information and a clearer understanding which will assist in increasing the successful implementation of computers into learning programmes. The quality and accessibility of hardware and software is now a minor problem for schools in developed countries. In all of these countries, problems of computer literacy of teachers and students are being addressed. What is left is a refocusing on the purpose and aims of schooling, reflection on the nature of learning and the problems schools have in facilitating learning, and the structuring of curriculum and schools to solve these problems. Then, provided teachers are given sufficient support and are permitted time to reflect on their own practices and experiment with solutions, computers will find a natural place in schools, fully integrated into the learning programmes to support student learning.

**REFERENCES**


This paper acknowledges the new educational possibilities provided by the Internet, as well as identifying its current limitations as an educational medium. Issues of concern in using the Internet include equity and access, infrastructure considerations, intellectual property, development methodologies, implications for the delivery and administration of education, and the relationship between the Internet and other new media in education, including audio/video tapes, computer aided learning software, videoconferencing and CD-ROM. While the Internet offers valuable opportunities to enhance all modes of teaching and learning, and it is likely that most of the current limitations of the Internet in this regard will be overcome in time, those developers currently pursuing or investigating the Internet as a teaching resource should be aware of the potential difficulties. This paper draws on the experiences of the author in conventional and distance university teaching, and in using the Internet as an aid to teaching and learning in engineering and technology, but the issues addressed apply generally to those using the Internet in education.

New Educational Possibilities

Despite certain misgivings, that will be identified, in part, below, there is little doubt that, just as computer and communication technologies pervade many aspects of our lives, computers have many roles to play in education. These roles include not only classroom teaching and learning experiences, but also administration, teacher training, the planning and development of educational material and general communications.

When the ‘power’ of global networked communications is added to computer applications we have the Internet. The Internet offers a new range of educational technologies to educators that includes: electronic mail, file transfers, the multimedia capability of the world wide web (WWW), low-cost, desktop video-conferencing, on-line, interactive tutorials, real-time group conferencing, remote access to laboratory experiments (Lemckert & Florance, 1996) and 3D interactive modelling.

For example, in engineering and technology education, computer applications can include computer programming, numerical analysis, computer simulation, computer aided design (CAD), computer aided manufacture (CAM), electronic communications, information retrieval and computer aided learning and assessment.

It is important to note that these new educational opportunities do not come without their own limitations, considerations and values. It is always important to remember that teaching technologies are not an end in themselves, only a means to deliver education: “Technologies do not teach; people do” (Ingram, 1996, p.31).

Equity and access

For a student to be able to participate in the new educational possibilities offered by the Internet, they must have access to the required computer hardware and software. On-campus students may have relatively easy access to computer labs and workplace-based students may be able to use the facilities of their employer, but off-campus students may have to purchase their own computer and communications hardware and software. However, simply having the requisite computer resources doesn’t automatically grant access to the information super-highway. If one is unfamiliar with computers or the Internet, attempting to navigate this new medium can be frustrating and frightening. Brogan (1997) reports in a survey of 158 post-graduate students, composed of roughly equal numbers of on- and off-campus students, that even though more than 90% of students had access to a computer, 75% of all students stated a need for training in the use of the Internet.
Even when everyone is ‘on-line’, not everyone may have the same type of connection. On-campus students may have the benefit of high speed, dedicated networking, whereas the only option for an off-campus student may be a dial-up modem line that does not support the data transfer rate required for high quality interactive multimedia programs (Ingram, 1996).

Once a student has access to the required equipment, they may face the additional and on-going cost of service access. Those who require only on-campus use of the Internet in computer labs may pay no direct access costs. Students living close the education institution may face only the cost of a local call to establish a modem connection to the Internet via their university. Students in remote areas may face more significant costs, perhaps even paying by the hour to a commercial service provider, to establish a reliable and reasonable speed Internet connection.

One approach to dealing with student access to the Internet is to simply make it a requirement for students entering a study program to have the necessary computer hardware and Internet connection. This may remove considerations of Internet access for those within the course, but it does nothing to address issues of equality of access to participation in education, and the barriers to participation created by the adoption of new technology (Milone & Salpeter, 1997). Where only on-campus students are involved, close control can be exercised over both the computing environment and the material presented to students. In this scenario one possibility is to employ a self-contained intranet, where all the material is preset and preloaded by the system administrators, and with no (or limited) connection to the external Internet (Long & Smith, 1996).

**Infrastructure issues**

Anyone involved in the administration and provision of Internet services will be aware of the large infrastructure costs, both capital and maintenance, necessary to provide the basic networking, computer hardware and software, staff training, and staff and student user support required simply to operate in a networked environment - estimates of the ‘total cost of ownership’ of a PC operating in a networked environment range from US$1,500 to US$9,784 (Francis and Johnston, 1997). On top of this comes the costs of the development of educational software applications that run in this environment.

In fact, when it comes to information technology (IT) infrastructure, it is almost pointless to talk about ‘capital costs’, as to maintain the currency and performance of computer hardware and software, they will need to be upgraded or replaced about every three years. In this environment, capital costs effectively become maintenance costs. The product lifecycle of computer hardware and software ensures that owners of numbers of off-campus students demanding full access to the Internet and other networked services. Many universities now find themselves offering the same access services to their students that would be available on a fee-for-service basis from commercial Internet service providers (ISPs), but effectively charge nothing for providing these services. Not surprisingly, they find their access services constantly overloaded and a significant financial burden, to the point were several Australian universities are considering...
Introducing charges for dial-up access (Illing, 1996). Now that it has reached the point where universities are considering charging fees for dial-up access, the question must be asked, “should universities be attempting to compete with commercial service providers by duplicating existing infrastructure?”. One answer to this question can be found in the Information Technology Strategic Plan of Deakin University which assumes that by the year 2000, “90 per cent of all external access to Deakin University IT facilities will be via commercial providers” (Information Technology Strategic Plan, 1997, p.5).

**Copyright and intellectual property**

Historically, educators have enjoyed some freedom with the normal provisions of the Australian Copyright Act in relation to print materials to be used for education. However, these freedoms apply to facsimile copying only, they do not extend to reproduction or transmission via electronic means (Course Development Centre, Deakin University [CDC], 1998). Reproduction in a digitised form requires the permission of the copyright holder. This requirement places restrictions on the use of third party materials when the medium of transmission is the Internet, copyright clearance may take a long time to obtain, or not be granted at all. Under the current copyright legal framework it is not legal to simply take existing print-based course materials that contain items subject to copyright and digitise them for distribution via the Internet.

It should be noted that the Australian Copyright Act is currently under review by the Copyright Law Review Committee (CLRC). The review is a response to concerns that the Act is out of step with technological developments, such as electronic publication and distribution via the Internet, and that it has become unnecessarily complex (CLRC, 1995). In a 1994 report of the Copyright Convergence Group (CCG) (a group formed in 1993 to propose legislative changes to the Copyright Act) one of the recommendations was that a ‘technology neutral’, broad based right to authorise transmissions be introduced into the Act (CCG, 1994). Such a development, subject to other changes to the Act, would remove the current restriction that limits the educational use of material subject to copyright to print form reproduction only.

In addition to the concerns about the use of third party material on the Internet, there is also the related issue of protection of the intellectual property embodied in documents that may be transmitted over the Internet. This issue is of particular importance to the developers of educational courseware, as a substantial investment may have been made in development of these materials. Traditionally, course materials were printed, affording at least some protection against misappropriation (other than direct photo-reproduction) in that the material would have to be manually re-keyed or otherwise accurately digitised before it could be reproduced. When documents are transmitted using the Internet, particular via the WWW, a complete electronic version of the source file is sent to the remote computer so that it can be reconstructed on the computer screen. This file can be easily captured by the remote computer, providing the reader with the entire source material for the document already in electronic form.

**Development methodologies and issues**

The Internet is an all-embracing label for a suite of computer network communication services that includes email, newsgroups, Telnet, file transfer protocol (FTP), Gopher, wide area information server (WAIS) and hypertext transfer protocol (HTTP). These services primarily support the transfer of text-based information and files. The hypertext transfer protocol supports the transfer of multimedia elements including text, graphic images, audio files, and animations, and is the underlying transport mechanism of the WWW. It should be noted that the development of educational materials for use with the Internet is almost exclusively confined to the WWW, this is due to WWW offering support for text, graphics, animation and other multimedia elements, as well as permitting a high level of interactivity. When approaching the development of materials (educational or otherwise) for the Internet, it is important to be aware of the available development methodologies.

It is possible to perform a straightforward and relatively automatic conversion of existing print-based materials, particularly if they already exist in electronic form. Many wordprocessors now have options to save documents in hypertext markup language (HTML) format, the file format required for transmission over the WWW. While this approach offers cost advantages, there may be significant disadvantages, depending on the particular application. If the original material contains items developed by third parties and incorporated in a print-based form under the guidelines of Copyright Act, then copyright clearance will have to be sought for each item if it is to be transmitted electronically via the Internet. Any items in the source...
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document that aren’t in electronic form, such as third party figures and tables or hand drawn diagrams, will have to be digitised or electronically re-drafted for inclusion.

Where the source material is print-based, a direct conversion for display on a computer screen may produce a result that is less than visually appealing. What looks good on paper, may not work well on a computer screen, for example, the average computer screen is not long enough to display an entire page at once, requiring students to continually scroll down while reading. Significant reformatting of the source document may be required to appropriately adapt it to the new medium. The literature related to the readability of computer screens suggests that while the presentation of text on a computer screen does not significantly reduce comprehension, it does impact on reading speed, with the printed page being easier to read than a computer screen, and larger screens being better than smaller screens. Additionally, most readers report a preference for reading the printed page over a computer screen.

The preceding paragraphs have been inferring that designing learning resources for the WWW requires an additional set of skills and resources that includes design of screen layout, hypertext markup, development of multimedia elements such as audio and video clips, WWW document editing software and access to the WWW/Internet. Editorial and instructional design staff who are experienced in the development of print-based materials will require additional training to create materials that use the WWW effectively. Since the advent of wordprocessors and laser printers, just about anyone can create a professional looking printed page but not everyone can present the content in such a way that leads to effective learning. The same can be said for the WWW, with the same wordprocessor, just about anyone can easily create a WWW page, but there are still few people with the knowledge and experience to create WWW learning materials that have a sound basis in educational theory and take full advantage of the new educational possibilities offered by the WWW.

If Internet-based learning resources are to be developed without the use of dedicated editorial or instructional design staff, then the task must fall to specialist consultants or project officers, or to general academic staff. If the task is to be delegated to academic staff, then they too will require individual training and development if meaningful, effective and consistent results are to be obtained. To simply expect that academic staff with a wide variation in computer and Internet literacy and perhaps limited knowledge of instructional design principles will magically produce quality Internet courseware, without appropriate training, is unrealistic.

Apart from human resources, effective and efficient development of WWW-based learning materials requires specialised and dedicated computer hardware and software. While it is possible to create WWW pages using a standard wordprocessor, there exist specialised WWW authoring programs that provide an integrated development environment encompassing text, graphics, colour, sound and animations, as well as document control and management functions. To develop full multimedia applications requires the addition of specialised hardware to a standard computer, including optical scanning capability, audio and video recording and playback, CD-ROM, large amounts of memory, mass storage, and a network connection to the Internet.

Implications for the delivery and administration of education

Once a university, or even an individual has decided to employ Internet-based teaching technologies, there are other issues and problems that are likely to arise. Some of those considered above include, will student access to the Internet be compulsory/essential?; are the necessary hardware, software and network resources in place?; if not, will they be provided centrally by the university, or must the faculty/school provide them? Similar questions need to be answered regarding staff training and development; who will fund the capital and on-going system costs?: and what development methodology will be used to create the learning materials? A fundamental consideration in answering most of these questions relates to the nature of the development exercise, is it intended as a ‘one off’, special project to create an item,
or items of specific courseware, or is it intended as an on-going and ‘normal’ part of the courseware development and delivery process?

The development of WWW-based learning materials is similar in nature to conventional software development. This suggests that the difficulties experienced in accurately estimating software development costs (Kusters, van Genuchten & Heemstra, 1990) are likely to apply to WWW courseware development as well.

While many of the same difficulties arise when using the WWW for teaching both on- and off-campus students, at least the on-campus computing environment is normally under the control of the teaching institution. The nature and variability of the off-campus computing environment, which is normally under the control of individual students, leads to many problems, some of which are described below. Given that one of the primary justifications for pursuing developments in this medium is ability of the Internet to bring education to students, via the communications network, regardless of their location, then the organisation of effective off-campus computing is crucial.

First of all, off-campus students have to get connected to the university’s network, which normally means a dial-up modem link. Communications software and details of the procedure for connecting to the university’s network must be provided to students. Normally, there will also be some bulletin board or other user interface to the network that the student must use to access specific subject-related and general resources, documentation for using this system must also be provided. Some of this documentation is likely to be produced centrally for universal distribution, and the rest will be produced by faculties/schools to deal with course-specific details. All of which must be coordinated and delivered to off-campus students.

Anyone who has been involved with off-campus computing will be aware of the wide variety of problems experienced by students attempting a modem dial-up connection. Such problems are typically caused by incorrect configuration of the student’s modem and/or communications software, or because the student simply does not have the knowledge of computing necessary to understand the directions given in the documentation provided, but, may be caused by problems as difficult to diagnose as corrupted files on the floppy disks used to distribute connection software to students.

Problems of this nature can provide difficulties for a computer ‘expert’ on the spot, so it is not surprising that they can be extremely difficult to diagnose by ‘remote control’ when a student calls the university computer centre and says, “I can’t get it to work”. Where the system is comprised of centrally supported computing infrastructure, special resources developed by the faculty/school and the remote student’s equipment, attempting to pin down the location and nature of a problem can be virtually impossible. If the student cannot access expert assistance locally, it is not uncommon for such problems to remain unresolved, with the student simply never getting ‘on-line’.

Once initial courseware materials are developed and students are connected to the network, the issue of administration of on-line teaching must be considered. Authors of WWW learning materials normally include contact information, in keeping with the nature of the medium this is often in the form of an email address. If the number of students accessing the material is large, the author may find themselves inundated with questions, request and comments sent via email. While some of these electronic requests will replace enquiries that would have traditionally been made by the telephone, fax or post, the ease with which students can create and send an email message is likely to lead to a net increase in their demand on academic staff time. Where electronic communication is designed to be an integral component of the course, such as a discussion group, bulletin board or email list, the new administrative load can involve supervision, housekeeping, responding to direct enquiries or general questions from the group, moderation of discussions and production of summaries or digests of discussions. Even where there is no planned electronic discussion, and the materials are simply placed on the WWW for students to access and read, there is still a need to keep this information up to date and evolving if the desire is for students to visit the information regularly. A static WWW site is soon recognised as such, and students lose the motivation to regularly check back to see ‘what’s new’.

There exist a number of integrated applications that provide a framework for the development and management of on-line (particularly WWW-based) teaching and learning resources. These applications include Learning Space from Lotus, Virtual-U from Virtual Learning Environments Inc, WebCT from WebCT Educational Technologies and Top Class from WBT Systems. The typical features provided by these systems include operation via the WWW, email, file exchange, newsgroups, self-assessment, testing and progress tracking tools for students, course planning and management, instructional design tools, grading and results analysis, and security tools. The benefits of these systems are their integrated development and management environment and their abstraction of the user from the underlying WWW and database technologies.

Relationship with other new media

‘Multimedia’ and ‘new media’ are somewhat overused terms in education, but the various technologies that fall under these headings can be valuable teaching tools (Satran, 1994). By definition, ‘multimedia’ refers to a communications system that combines more than one media, this then includes audio and video tapes, interactive computer programs, computer aided learning (CAL) packages and videoconferencing. The WWW is generally included as one of the new media, so a comparison of the WWW with some other of the new media is valuable.

Where the aim is to provide learning resources to off-campus students
without the requirement that the students have access to a computer or the Internet, then print-based materials supported by audio and/or video tapes are likely to be the preferred option. Compared to the WWW, print materials have limited interactivity and cannot be updated without forwarding revised materials to the student.

Virtually all of the functionality that can be provided by a dedicated CAL package or a computer simulation program (such as animations and interactivity) can now be provided by the WWW, thanks to recent developments in the WWW programming language Java. If students do not have access to the Internet, then dedicated computer programs have the advantage that they can be distributed on a floppy disk or CD-ROM. The advantage that the WWW has here is that WWW applications are independent of the computer platform that the students uses, whereas dedicated CAL/simulation programs must be developed for each possible platform the student may use.

Currently, if videoconferencing is to be employed, the best results are still obtained by using a dedicated videoconferencing system that is based on special image compression hardware and high speed digital communications channels, such as ISDN. However, recent developments in WWW-based videoconferencing, using only a Pentium computer, standard telephone line, video compression card and low-cost camera are impressive to say the least (Adams, 1996), and will bring videoconferencing for education applications into the realm of individual students.

If an application requires large amounts of digital information to be accessed, searched or transferred in a short time, then CD-ROM technology is currently probably the best solution. All of the same functionality can be delivered with the WWW, but data transfer rates across the Internet are (currently) no match for having a CD-ROM installed locally in your computer. Additionally, a local CD-ROM does not suffer from availability problems caused by network failures or modem drop-outs, and does not slow down to a snail’s pace because large numbers of users are trying to access it at the same time. The downside of the CD-ROM is that the large amounts of data on the disk are as permanent as a book, and revisions require the issue of another CD-ROM, whereas a WWW site can be updated frequently and quickly. New, hybrid applications are combining the best characteristics of both CD-ROM and WWW technology - large amounts of static data can be placed on a CD-ROM, along with automatic links to WWW sites that contain software updates and/or the latest supplementary information (Pardhu, 1996) and (Hyams, 1996).

**REFERENCES**


**Conclusion**

This paper presents a series of issues and limitations for consideration regarding the use of the WWW in teaching and learning applications. There is no doubt that time, and with it developments in technology, custom and the nature of education will overcome many of the current limitations and render irrelevant many of the current issues associated with using the Internet in teaching and learning. The passage of time will, no doubt also bring new problems and new issues to be considered. For those currently working in this area, the limitations and issues identified herein are important and must be considered.
Opening school doors to the real world: A review of literature on computer mediated communication and its role on the creation of constructivist learning environments

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Constructivist learning theory has cognitive, social and cultural elements. A problem-solving approach is consistent with principles of instruction arising from constructivism, and is commonly observed in applications of computer mediated communication (CMC) in education. The nature of problems posed for solution, and the contexts for their solution, affect the nature and quality of learning. Many of the documented applications of CMC reflect the limitations and difficulties imposed by the constraints of formal school environments. Technology can be leveraged to help change schools and their communities into constructivist learning environments.

This paper uses a review of literature to assess the role computer mediated communication (CMC) might play in the creation and support of constructivist learning environments. The review covers theoretical perspectives on constructivist learning, the nature of learning environments, constructivist applications of CMC in primary and secondary schools, and the role of CMC in curriculum and school restructuring.

Theoretical perspectives on constructivism

Constructivism is often invoked in the context of discussions of the use of CMC in education. One of the primary propositions which characterises the constructivist view of learning involves the concept of cognitive dissonance, which refers to a cognitive conflict or incongruity requiring resolution (Savery and Duffy, 1995:31). The proposition is that such an incongruity provides the stimulus for learning and largely determines what the learner attends to, what prior experience the learner brings to bear in constructing an understanding, and what understanding is eventually constructed. The learner has a purpose for learning.

While the constructivist view is usually broadly understood to involve a process where the learner is actively creating his or her knowledge, perspectives on constructivism vary. The main emphasis of Piaget’s work has been on mapping distinct stages of cognitive development. This emphasis has led some writers, such as Edgar (1995), to see constructivist theory as an individualistic and narrowly cognitive theory. However, the writings of Piaget also refer to the significance of collaborative work and of experience in the social/cultural environment (Hilgard & Bower, 1981; Ridgeway & Passey, 1991). Greater emphasis was placed on these factors in the work of Vygotsky (1986). Researchers have described a number of theoretical perspectives which reflect this broader view of constructivist learning. These include descriptions of sociocognitive learning (Needles & Knapp, 1994), situated learning (Brown, Collins & Duguid 1989), and social constructivist learning (Cobb et. al., 1992).

An issue central to the subject of this literature review, and about which there is some confusion and disagreement, concerns the notion of authentic tasks and experience. As has already been noted, central to the constructivist view of learning is the notion that learning happens when the beliefs, theories and perceptions of people are challenged. The learner’s motivation to resolve that challenge provides the learning task with its authenticity. Constructivists with a cognitive leaning (e.g., Turner, 1995) would emphasise mental challenges as constituting constructivist learning tasks. Constructivists with a social leaning (e.g., Knapp & Glenn, 1996) would emphasise conversation and collaborative activities as constituting constructivist learning tasks. A constructivist with what I might call a cultural leaning (e.g., Perkins, 1996) would emphasise hands-on and real-life experiences as constituting constructivist learning tasks. Each type of learning task may be valuable. Each approach may involve providing opportunities for problem-solving, but the nature of the problem, and the context for its solution, make a very large difference to the nature and quality of the learning.
The nature of learning environments

The distinction drawn by Marshall (1992) between work-oriented and learning-oriented classrooms reflects the constructivist perspective. Teachers in work-oriented classrooms concern themselves with transmission of information, whereas those in learner-oriented classrooms facilitate the active construction of knowledge through an emphasis on problem-solving and understanding.

Savery and Duffy (1995:33) suggest that one of the vital principles in the social constructivist perspective is the ‘social’ part, that is, the characteristics of the learning environment, the context of learning.

Rather than simplifying the environment for the learner, we seek to support the learner working in the complex environment. This is consistent with both cognitive apprenticeship (Collins, Brown, & Newman, 1989) and cognitive flexibility theory (Spri et al., 1992) and reflects the importance of context in determining the understanding we have of any particular concept or principle.

Several writers have attempted to describe what might constitute an effective constructivist learning environment and a variety of terms has been coined, including ‘community of learners’ (Brown & Campione, 1994), ‘knowledge building communities’ (Scardamalia & Bereiter, 1992), and ‘constructivist learning environments’ (e.g., Morrison & Collins, 1995; Wilson, 1995). Perkins (1996:vii) suggests that learning environments help us to ‘know our way around’, which includes:

...having a sense of orientation, recognizing problems and opportunities, perceiving how things work together, possessing a feel for the texture and structure of the domain. It encompasses not just explicit but tacit knowledge, not just focal awareness but peripheral awareness, not just a sense of what’s there but what’s interesting and valuable, as urged by Michael Polanyi (1958). Better than knowing that, knowing how, or like names for knowledge, knowing your way around resonates with the notion of a learning environment.

In seeking to create constructivist learning environments, Savery and Duffy (1995) suggest we attempt to preserve the richness and complexity that draws people into a context or activity in the first place, while providing tools and supports to ‘learn our way around’.

Similar to Perkins’ idea of ‘knowing our way around’ is the notion of epistemic fluency described by Morrison and Collins (1995). Epistemic fluency is the ability to participate in different culturally patterned ways of constructing knowledge, “…to recognise and practice a culture’s epistemic games, with their associated forms” (Morrison and Collins, 1995:43).

Epistemic forms are “target structures” that guide inquiry. Examples include lists, stage models, hierarchies, systems-dynamics models, and axiom systems. Epistemic games are sets of moves, constraints, and strategies, that guide the construction of knowledge around a particular epistemic form.

(Morrison and Collins, 1995:40)

Epistemic forms and games are language- and culture-based. The development of epistemic fluency takes place in the context of social interactions with other members of a culture who are more fluent than the learner, and where authentic, purposeful projects are the dominant activity (Morrison and Collins, 1995:43).

A number of writers conclude that teachers cannot fulfil the demands of providing an effective constructivist learning environment on their own (Goldberg & Richards, 1995; Jones et. al., 1994; Mandinach & Cline, 1994; Morrison & Goldberg, 1996; San Carlos Charter Learning Center, 1997; Xiaodong et. al., 1995). The challenge of finding ways to involve community members would seem to be inherent in our attempts to create constructivist learning environments.

Technology and constructivist learning environments

Morrison and Collins (1995) suggest that technology can play some role in the development of epistemic fluency, but only if the technology supports and is supported by a constructivist learning environment. They describe a variety of software environments that can help students develop certain kinds of epistemic fluency. These include stand alone ‘communication’ environments that allow users to manipulate symbols and organise textual information; tools or construction kits, such as spreadsheets, that support students in carrying out tasks, and; interactive simulations and models, such as SimCity, which help students to create and observe scenarios (Morrison and Collins, 1995:43-4).

However, some writers observe that the use of technology as a constructivist learning activity in itself, represents a significant impoverishment of reality (Apple, 1987; Boudourides, 1995; Postman, 1992; Postman, 1995). Postman (1992:20) suggests that:

New technologies alter the structure of our interests: the things we think about. They alter the character of our symbols: the things we think with. And they alter the nature of community: the arena in which thoughts develop.

Morrison and Collins themselves, recognise the limitations of software environments in developing real epistemic fluency. They assert that schools will benefit most from “...communication tools that extend the community of practice to include participants from beyond the school walls” (Morrison and Collins, 1995:44), that is, from the appropriate use of CMC.

Many of the documented applications of CMC in education reflect the limitations and difficulties imposed by the constraints of traditional school environments. Typically, where CMC is used in conventional classrooms, in the study of conventional subjects, it is used as a source of information to assist with research, and as a link between locations, enabling personal communication such as computer pals activities, collaboration and sharing of information across cities, countries or continents (Harris, 1995; Poole, 1993). However, as Morrison and Collins (1995:43) point out, improved “…access to information probably contributes about as much to epistemic fluency as watching a tennis match does to learning how to play the game”.

Savery and Duffy (1995) argue that the problem-based learning model of
Barrows (1985, 1992) is consistent with the principles of instruction arising from constructivism. In fact, a problem-solving approach is commonly observed in applications of CMC in education, and a number of writers point to the value of CMC in supporting project-based learning. According to Joseph (1996) and Meagher (1995), the use of CMC in the learning of English supports the pursuit of projects relevant to the real world. They identify other benefits as improved motivation to research, collaborate and learn, more responsibility assumed for learning, and improved metacognitive skills due to having a real audience.

While many of the reported benefits of using CMC in traditional classrooms are significant, it has not been shown that such use leads to fundamental improvements in the nature and quality of learning. Such use does not reflect a substantial shift to education characterized by instructional principles that reflect a social constructivist perspective. The increased use of collaborative groups, for example, is a commonly observed concomitant of the use of CMC. But as Savery and Duffy (1995:32) point out, "...the real issue is what the goal is in using collaborative groups, since that determines the details of how they are used and how they are contextualized in the overall instructional framework."

This is a conclusion echoed by Topper (1995) who states that, "Simply applying technology toward collaborative learning without consideration for the complexities of social interaction and communication has not proven successful".

The nature and context of the problem solving activities tend to reflect the ways teachers or researchers understand constructivism, and the assumed or actual physical, organizational and curricular constraints within which learning activities take place. Turner (1995), for example, acknowledges that formal school structures hinder the implementation of constructivist curricula, and describes attempts by staff at his school to develop "computer constructivism" (not involving CMC) within the context of a ‘constructivist classroom’. Such attempts to apply constructivist principles reflect Riel’s (1992) recognition that in most instances education will not change if innovative activities cannot take place in the classroom, at least initially. However, such an application of constructivism is largely cognitive in character, and suffers from the limitations of software environments identified above.

Within what sort of learning environment, then, can CMC support real, socially and culturally conceived constructivist learning? Xiaodong et al., (1995:59) identify five key principles that can be used as we attempt to design and develop efficient, constructivist learning communities. Such communities would provide students opportunities to:

1. plan, organize, monitor, and revise their own research and problem solving;
2. work collaboratively and take advantage of distributed expertise from the community to allow diversity, creativity, and flexibility in learning;
3. learn self-selected topics and identify their own issues that are related to the problem-based anchors and then identify relevant resources;
4. use various technologies to build their own knowledge rather than using the technologies as "knowledge tellers"; and
5. make students’ thinking visible so that they can revise their own thoughts, assumptions, and arguments.

While many of the characteristics of constructivist learning environments have no inherent dependence on CMC (e.g., Conrad & Hedin, 1991; Hedin, 1983; San Carlos Charter Learning Center, 1997; Williams, 1991), it can clearly play a significant role in supporting and applying several of these key principles. However, the application of such principles clearly necessitates substantial restructuring of curriculum and school organisation, and Goldberg and Richards (1995:6) suggest that "...technology can be leveraged to change schools and their communities into learning organizations".

**Curriculum and school restructuring**

Goldberg and Richards (1995) describe the Co-NECT school design and suggest that it provides a framework for school-wide restructuring that schools can use to change traditional rules, roles and relationships into those of a true learning organisation. Morrison and Goldberg (1996) characterise the Co-NECT school design as one that focuses on technology integration, multi-grade clusters, team teaching and decision-making, performance-based assessment, and strong parent and community involvement.

At the center of the Co-NECT design is a vision of students, teachers, and other community members working together on a variety of significant projects of compelling interest and value to themselves, and to the larger community. (Morrison & Goldberg, 1996:216)

Jones et al., (1994) also recognize the necessity of significant school reform to enable the creation of effective, constructivist learning environments, and the role technology can play in facilitating that reform process. They identify curriculum reform as a key issue.

In order to have engaged learning, tasks need to be challenging, authentic, and multidisciplinary... Collaboration around authentic tasks often takes place with peers and mentors within school as well as with family members and others in the real world outside of school. These tasks often require integrated instruction that incorporates problem-based learning and curriculum by project. (Jones et al., 1994, paraphrased in North Central Regional Educational Laboratory, 1997)

Issues of curriculum development, integration and course sequencing are noted by several writers (Mandinach & Cline, 1994; Morrison & Goldberg, 1996; Roberts et. al., 1990; San Carlos Charter Learning Center, 1997) as complex issues that need to be addressed in greater detail. Morrison & Goldberg, (1996:217) observe that "...the Co-NECT design acknowledges that projects are not the only suitable context for learning, and suggests that schools offer what the design refers to as ‘seminars’ and ‘workshops’".

Assessment is also a significant issue addressed by a number of writers (e.g., Goldberg & Richards, 1995; Knapp &
Opening school doors to the real world

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Implementing new generation instructional information management systems: A Western Australian example

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In the context of planned change it is argued that information management for decision support is crucial to innovation and implementation success. A new generation of instructional information management systems (IIM Ss) is now becoming available at affordable prices and some of their characteristics are described in this paper. These computer systems seek to integrate the school community with the web of relationships between curriculum, teaching, assessment and school organisation. Following professional development activities an IIMS User and Non-user Group of teachers and administrators, in a remote area school in Western Australia, were surveyed in order to discover some of the early implementation difficulties in employing this technology from a user perspective. It is concluded that IIM Ss have the potential to enable schools to monitor their performance more effectively, with subsequent benefits accruing to teaching, learning and professional collegiality.

It has become increasingly evident that, within a global information society, those who can access information, transform information and create information are substantially advantaged by all the indices of success in the post-industrialised state, while those who cannot create and transform information are increasingly dependent on those who can. New technologies construct a totally new environment, and this radically alters the way we use our senses and consequently the way we act and react to things. Thus, the restructuring that necessarily occurs as a consequence of introducing new technology enters practically every facet of our lives. Changes come, therefore, because of the application of new technologies and it does not matter so much about the details of the content. The medium is the message. The inevitable transition to a computer based classroom offers major challenges and new opportunities for teaching and learning, empowering us to break the lock of structures and the inertia of tradition that has tended to constrain change managers to accept these as givens in their efforts to reform schools and education systems (Carter and O’Neill, 1985).

Managing Information

In spite of the huge, and continuing, expenditure of resources in time, money and human endeavour recorded in an enormous body of literature on curriculum innovation and change, this effort has not been noteworthy to date in bringing about changes of the order and scale required to have a noticeable and durable effect on school systems and educational practice.

Traditional curriculum models, if they worked at all in guiding practice, did not take into account one of the major realities of life very obvious to those who administer and teach in schools. It is the generation, flow and management of information that in the past has substantially acted as a bottleneck to, rather than enhancing the implementation of, curriculum and innovation for school improvement, and the raising of school achievement in line with individual entitlements and societal expectations. The basis for conceptualising and integrating curricula with both their internal and external environments lies in, and increasingly must rely on, information management to guide and inform design and implementation decisions, made on behalf of an increasingly complex society and its stringent mandates for schooling.

Well constructed Information Management Systems (IIM Ss) are designed specifically to allow for the unobtrusive and automatic acquisition of data describing the key operations associated with the interlocking cycle of relationships between curriculum, instruction and assessment (Hextall, 1988). A variety of data are crucial to determining program effectiveness and can serve to guide school improvement processes. Accountability, in the sense of being able to define precisely and show relationships between system
New generation information technology can assist tremendously with the design, development, evolution and alignment of curricula across system to classroom levels of schooling. It provides, for example, the means for monitoring which curriculum elements are included in daily lesson plans, student grouping practices; ‘at-risk’ students; the development of teacher made learning materials; the management of material resources; the form of assessment programs across different time spans and subject areas, and curriculum alignment to external references, benchmarks and standards on a continuous, routine and substantially unobtrusive basis (Carter, 1993). The curricular structure for a particular IIMS for use in outcomes-based programs is shown in Figure 1.

Figure 1: An Hierarchial Arrangement of Curriculum Elements for Information Management

**CURRICULUM & OUTCOMES HIERARCHY**

**CROSS REFERENCES**
The Rationale for Instruction
What should the outcomes of instruction be?
What are we trying to accomplish?

**I:** Categories of Standards/Exit Outcomes
National, State, Local, Professional, Curricular, Assessment, Life Roles

**II:** Broad Skill/Knowledge Outcomes
General Proficiency/skill areas: discipline or performance based

**III:** Specific (vocational/societal) Outcomes
Skill knowledge by discipline or proficiency area

**IV:** Operational Statements
Specific statements describing behaviour/actions based on skill or knowledge demonstration

**V:** (Operational Statements - optional)

**DEPENDENT RELATIONSHIPS**

**LINKED RELATIONSHIPS**

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Variables and desired outcomes, proves to be an important but elusive task without recourse to technology to meet the increased societal expectations of schools and ‘value for money’ for the educational resources expended.

At the junction of instruction with learning the introduction of the microcomputer together with advances in communications technology provides us with the potential to revolutionise both, as well as the organisational structures in which they conventionally take place. In short the computer, when interacting with a professionally informed mind, acts as a magnifier of human capacities that allows us to perceive yet further possibilities previously beyond our comprehension.

The intellectual tools to support instructional leadership through the management of information to guide and inform data-based decision making are already becoming available at affordable prices. Sophisticated IIMSs which combine those functions that lie at the heart of schooling, such as curriculum development, instruction, evaluation and assessment, allow for the formation of information rich environments with great transformative potential.

For example, the form a curriculum takes is not simply two dimensional in its scope and sequence, except perhaps in its documented form. The curriculum, as lived out by students in schools and classrooms is multi-dimensional, and thus two-dimensional models appearing in a range of curriculum documents do not, and cannot, adequately represent the dynamic nature of learning context, curriculum processes and associated knowledge structures which also have to be addressed in the process of curriculum decision making. To be responsive to these, the curriculum of each school has to be locally crafted in order to capitalise on local talents, with local insights in order to meet local needs. Sophisticated IIMSs enables instructional leaders to determine the curriculum scope and sequence they desire, while enabling each of their teaching staff to be actively engaged in curriculum development activities in an on-going way.

Because the IIMS automatically records detailed audit trails as staff members use it, supervisors can obtain profiles of how the performance of students and/or teachers are changing, by viewing sets of records accumulated unobtrusively through the daily operations of the school over selected periods of time.

There are two ways of using technology in information rich environments. One is for the purpose of automating: the other for informing. While there are some who clearly seek to use technology for the former purpose, it tends to become mechanistic and to isolate the human element from the process itself. Automating then is not a satisfactory means for supporting teachers and administrators and for educational problem solving. To ‘informate’, however,
is to empower educators as professionals. It is in this context that curriculum leaders can work with staff in order to resolve the question of what information has to be readily available and easily accessible for them to both understand and execute certain educational processes and curricular events.

**Instructional Process**

Research on schools and into teacher effectiveness has shown that instruction makes a difference. For the full potential of this to be realised, teachers must be able to capitalise on new knowledge, exercise data-based professional judgements, and acquire intimate knowledge of the changing needs of the learner in the exercise of their own creativity and spontaneity. While a well designed curriculum, aligned with appropriate instructional processes, is regarded as fundamental to helping each student achieve mastery of course objectives, slavish adherence to the textbook and detailed attention to every textbook and detailed attention to every objective in the curriculum is not a means to achieving the desired outcomes. In effect, it is likely to work against the desired result of raising student achievement.

For the instructional context and learning environment to be rich, a process orientation in which a variety of instructional strategies must be present, with students afforded the opportunity to read and discuss much more widely than is directly required for the immediate achievement of the objectives, is required. It is also important to realise that it is not necessary and even ill advised to seek to control all the activities that take place under instructional processes. Rather teachers have to be able to ascertain their nature at will, and to direct them differentially to learners as needed, and in the full knowledge of the extent to which external agencies are also influencing and guiding instructional processes.

With the curriculum on-line, data accumulates unobtrusively through the normal operation of the school and the ongoing processes of education. Accumulated data that ‘captures’ the functions and operations of the school from, curriculum development, lesson planning, student, parent and teacher, and assessment points of view, and cross-referenced to external standards can now be managed with a pedagogically driven IIMS.

Archived data, ordinarily lost to the school and the system but now unobtrusively and continuously accumulated through the normal operation of school routines, can be queried, probed and structured in ways that support research into the operation and functioning of the school, including its intellectual, social, economic and organisational aspects as a form of problem finding, and problem solving. Obvious uses here, for example, are for the management and utilisation of the schools’ material resources; the conduct of program evaluations and audit trails; supervision of beginning teachers and the induction of new staff; performance appraisal (where access to on-going data can readily support formative processes) and the tracking of ‘at risk’ students.

**Case Study Setting**

The case study high school is located in a mining town in a remote area of Western Australia. An evident feature of rural schools is that they are characterised by a relatively higher staff turn-over, when compared with metropolitan schools, and consequently they tend to have a relatively larger proportion of inexperienced staff than city schools. The 1994 report ‘Schooling in Rural Western Australia’ raised public concerns about the inexperi- ence of rural teachers in the following terms:

> In the ... District ... more than half have less than five years’ experience, and only one in seven has more than fifteen years’ experience and one in ten more than twenty years’ experience.’ (Tomlinson, 1994; p. 70)

From a costs and benefits point of view, these statistics are important to change managers considering the wholesale adoption and implementation of IIMS technology. Mainly, this is because of the requirement for a high initial investment in system software and hardware for most schools, and also for a continuing investment in staff development in IT use. Without the latter the potential benefits to students are likely to remain unrealised, and, having made the initial capital investment, the retention of trained staff becomes an important issue in all schools - but remote area schools in particular.

These considerations were germane to the decision to upgrade staff computer literacy skills in the context of moving towards the full implementation of new information management technology across the case study school. Prior to the adoption of IIMS technology and its subsequent implementation in the school, a considerable amount of groundwork was done by the Principal who had had previous experience with information management technology. He determined to 'unfreeze' the school’s organisational climate by using advocacy as a change tactic in order to engender staff receptivity for IIMS use in supporting school improvement processes.

While IIMSs are capable of integrating the administrative aspects of schooling with curriculum, teaching/learning and assessment, student monitoring and review, senior staff considered that there was an initial priority to narrow the IT focus, build staff confidence in the area, and give people tools and skills to become more effective in curriculum planning. It was reasoned that this would assist the adoption of student outcome statements which had recently been trialed on behalf of the State Department of Education in a single learning area. The planning focus would also orientate staff to computer managed learning in order to assist students achieve desired learning outcomes.

Participating Heads of Department shared the view that, while teachers tended to write term length teaching programmes and to submit them for validation; many did not interpolate specific lesson plans directly from their teaching programmes. Consequently, classroom level planning seemed to be both ad hoc and short term and did not appear to articulate well with other levels of planning. A further concern was that assessment items tended to be developed at the last minute, suggesting both the
lack of a medium term curriculum view and insufficient attention being paid to the alignment of purpose (i.e., Intended Learning Outcomes (ILOs)) with assessment during teaching program development. Given these supervisory concerns, the area of teacher planning and IIMS use became the focus for data collection. It also supported a longer term implementation strategy leading to full IIMS ‘take-up’ and use.

Principles of Procedure
As a precursor to implementing IIMS technology in the school, a group of high school teachers and administrators, together with two primary school teachers from nearby feeder schools, participated in a series of seminars on curriculum and information technology professional development workshops. The workshops focused on curriculum planning using an integrated Instructional Information Management System. The acquisition of new understandings and the mastery of IT skills took place sequentially and developmentally over the course of a whole semester. Professional development activities, aligned with the school development plan, afforded the participants an opportunity to use the IIMS as a planning tool, and enabled them to evaluate the implications of this technology for professional practice and school organisation.

Workshop participants who were trained to use the IIMS comprised eight teachers and administrators - six of whom came from the high school and two from feeder primary schools. They are referred to as the IIMS User Group in the survey data presented below. A second group of teachers and administrators within the school, but who had not undergone IIMS training, were also surveyed to ascertain the extent to which they already used computers to assist them with curriculum and instructional planning. This group is referred to subsequently as the IIMS Non-user Group.

Of the IIMS User Group, five staff members were Heads of Department, one was a subject teacher, and two were primary teachers (one a Deputy Principal and the other a Key Teacher). The age of those returning a short questionnaire eliciting self perceptions of their current and projected use of computers, was reasonably spread, and consisted of one aged between 20 - 29 years; three between 30 - 39 years; three between 40 - 49 years and one between 50 - 59 years. Three had taught for five years or less, two for between ten and fifteen years, and three for more than twenty years. The IIMS Non-user group consisted of six subject teachers and two Heads of Department also with a wide range of experience. Both groups represented a broad range of teaching areas.

Initially, a common questionnaire was to have been administered to all staff in the IIMS User and Non-user groups alike. During its development, however, it became readily apparent that there was a difference in the nature of the professional discourse between the two groups. Generic terminology, for example, such as ‘going on-line’, ‘curriculum alignment’ and even ‘Intended Learning Outcomes (ILOs)’ were unfamiliar to participants in the IIMS Non-user Group. Not surprisingly, curriculum concepts related to the IIMS were specific to the IIMS User Group. Because of this emergent realisation, the questions were modified to accommodate a broader range of curriculum terminology than that used in the first instance. Accordingly, a section was added to the questionnaire specifically for IIMS users, under the theme of ‘computers as an aid to planning’.

Discussion occurred between the Deputy Principal and two other senior members of staff concerned with the IT aspects of the school’s five year development plan, and the need to acquire information supporting prospective IIMS implementation referenced to student and teacher needs. Information was required for the implementation plan that would differentiate between staff who had undertaken IIMS professional development training and those who had not.

Teachers who had participated in the IIMS workshops were given a questionnaire asking them to reflect on their subsequent practice in using the IIMS as a planning tool. Samples of the open ended items are presented in Figure 2.

Figure 2: Sample Questionnaire Items

CURRENT PLANNING PRACTICES

Programming
Do you write programmes for the courses that you teach?
If your answer is yes:
• What do you use as an alternative for planning your course?
• If your answer is yes:
  • When do you do your programme planning (Choose from the list below)
  • Why do you write programmes?
  • What format do you use for programming?
• How do you use your programmes to link intended learning outcomes (or objectives) to instructional activities?

Lesson Planning
• What format do you use for lesson planning?
• How do you align your lesson plans to your teaching programme?
• In what ways do your programmes assist you at the lesson plan level?

Assessment
• When do you produce your overall weighted assessment outline/matrix for the courses you teach?
• When do you decide which intended learning outcomes or objectives to assess in each item?

• How do you link your assessment items to intended learning outcomes or objectives?

USE OF A COMPUTER WHEN PLANNING
(Please circle - 1 = Strongly agree; 5 = Strongly disagree)
I consider myself to be computer literate.
1 2 3 4 5
I have reservations about using computers in planning/preparation.
1 2 3 4 5
I am not confident in using computers.
1 2 3 4 5
I would be interested in using computers to make my planning more effective.
1 2 3 4 5

IIMS USERS
In what ways do you consider that an IIMS can assist you in your planning in the following areas:
• Aligning ILO’s with content and teaching/learning processes?
• Assessing effectively and validly
• If you were to use the IIMS for planning, what other ‘on-line’ information would you like to see?
The IIMS Non-user Group was given a parallel questionnaire asking members to reflect on their current planning practices - including their use of computers in planning. Responses to that section of the questionnaire eliciting self-perceived ratings, regarding computer use when planning, are shown in Figure 3. Sixteen questionnaires were returned, equally divided between each of the two groups of teachers. Fourteen of the total of sixteen participants, included in both User and Non-user Groups, were from the high school. The survey took place six weeks after the conclusion of the staff development seminar and workshop series.

Results and Discussion

While the survey was relatively modest in size and scope, fourteen out of a whole school staff of twenty eight afforded a reasonable representation of the situation concerning IT use at the school. Fourteen members of the whole group of Project participants used teaching programmes. Of these, only two did the majority of their planning at school. These participants made planning decisions involving the contemplation of course elements such as time, content, and assessments, although there were variously incorporated into their teaching programmes. Sixteen members included objectives, texts, and curriculum guidelines. One respondent that, "...he used to have a default for strategies, but didn't any more, thus variability in approach is driven by planning at the moment.

The IIMS User Group three respondents linked learning activities to objectives in their lesson plans. Four linked learning activities to content in drawing up teaching programmes. In the IIMS Non-user Group there was an evident lack of awareness concerning the linking and alignment of objectives with other course elements. A number of respondents did not see the item probing the linking of objectives to instruction actually occurred in their lesson plans and programmes. This may be related to the item probing the linking of objectives with assessment and instruction actually occurred in their programme development phase, and only assessed what they had actually taught. One respondent engaged this procedure intermittently, and assessed opportunistically, as students were observed to have developed course related skills and competencies.

Although they used different strategies, the IIMS User Group had a fairly clear idea about the ‘what’ and ‘how’ of linking Intended Learning Outcomes to assessment items. The Non-user Group participants were less clear about this, although all asserted that they constructed items based on objectives. The same pattern of responses occurred with respect to the linking of assessment items to specific Intended Learning Outcomes. This suggested that IIMS training in the area of curriculum and assessment greatly assisted in establishing curriculum alignment. When this occurs assessment articulates clearly with purpose and both can be referenced to student outcomes. Three of the IIMS User Group commented that, since completing the IIMS workshops, they had changed their assessment strategies. This was most evident when formalising links to student outcomes, and served to highlight the potential benefit to be gained in professional development activities, integrated with IT use, when following Outcomes-based or Criterion Referenced educational philosophies.

Within the IIMS User Group, seven respondents owned a computer and one was in the process of buying hardware. Only one did not use a computer when engaged in course planning. Five used computers for developing teaching programmes and writing up lesson notes; four for lesson plans and six for assessment items. Computers were also used to access electronic marking, for student worksheet development and subsequent archiving. Six of the IIMS Non-user Group owned a computer. Two did not. Thus, while ownership of computers in this group was almost as high as in the IIMS User Group, actual use of a computer as a planning tool was much lower.

In the Non-user Group, one used the computer for course planning including lesson plans and notes. Five
used the computer for lesson plans, and three did not use the computer at all for these purposes. A comparison of responses between the two groups concerning attitudes towards computer use for planning purposes, is summarised in Figure 3.

Given the ordinal nature of the data and the small size of each group, no attempt has been made to test for statistical significance. For the sample studied, there is a marked interest in developing more advanced skills in computer use generally, and in their application to planning using new information technology in particular. This proclivity is evidently more pronounced within the IIMS User Group. Several respondents are not at all confident that they are computer literate, and two participants are clearly not confident in using computers per se. Six respondents, however, are confident to very confident in using computers. This attribute may be used to advantage to support teacher workplace learning as IIMS implementation proceeds across the school.

There is a varied pattern of responses to the item regarding access to computers which needs to be investigated further because open access to computing facilities, including home use, is a basic requirement for encouraging widespread use of the IIMS across the school community. Generally, the results show that, while there is a cadre of people who are confident and competent in computer use within the school, there still needs to be a lot of preliminary work undertaken in order to develop generic skills and competence in computer literacy supporting IIMS implementation.

The final section of the questionnaire elicited information specific to the IIMS User Group. All respondents agreed that the IIMS was instrumental in enabling ILOs to be linked directly with instruction; in aligning contextualised internal relationships that occur between curriculum, instruction and assessment (Hextall, 1988), and in aligning all of these with external standards and benchmarks. Representative comments included:

"It has the potential to show exactly what objectives have been met and which haven't. It could keep track of what to teach", and,

"... being able to link folders and flick back and forth when planning lessons ensures that strategies link to and follow from intentions".

Six respondents agreed that IIMS technology had great potential in assisting teachers to assess student abilities more effectively than hitherto, and that it was easier to keep in view all relevant information and to keep track of the alignment. One teacher thought that, in theory, the technology had great potential in this area, but had doubts about its application in practice due to the ever present reality of time constraints.

Five agreed that future IIMS use would become very efficient. However, all also expressed concern about the need for large amounts of professional development time in the early implementation stages. Four noted the need for a lot of ‘on-line’ material to be stored if the process was to be justified as ‘time-efficient’. One commented that initially there would more work but little benefit to be gained in the short term. Further, he didn’t believe there would be any time-saving benefit in the long-run, noting that, "... computers do not save time, they shift focus." One commented that there would be no time-saving benefits because of the requirement to manipulate large quantities of data.

Other reservations and concerns from the IIMS User Group included:
- No time to input large volumes of data.
- Need to upgrade to more powerful computer architecture.
- Need to network computers.
- More IIMS specific professional
development needed beyond current levels.

- Security of information.
- Access to hardware and software.
- Having the hardware and software compatibility for systems to integrate effectively.
- Need for permanent technical support person on staff.

In sum, these comments relate directly to difficulties associated with developing computer rich environments per se. These are viewed by the workshop participants in terms of costs associated with acquiring and setting up equipment and systems, the fundamental requirement for technical support, data management and protection and the need for staff development and training. All of these problems extend beyond the case study school, and are well known to change managers seeking to capitalise on the benefits of technology transfer, yet recognising the inherent difficulties this brings (Hall and Carter, 1995).

School staff who have been introduced to and experimented with an IIMS have had the opportunity to use this new information technology to enhance their current planning practices as well as decision-support for computer managed learning (CML). They are now in a position to reflect on how this has changed their behaviour and thinking with regard to planning and cognate professional activity. A number of participants in the IIMS User Group have reported that they’ve revised their ideas on planning, and as a result have changed their approach to teaching and learning.

There has been observable changes in language, discourse and social groupings in the school since the IIMS workshops concluded. The IIMS User Group continues to use the language of IT and curriculum, and, while it hasn’t become a distinct social group within the school, members share an informal and common professional identity. User Group members recognise that they have become a collegial source for sharing ideas with other staff concerning IIMS technology, its ‘take up’ and use as the early phases of implementation proceed.

Conclusion

In this paper it has been argued that IIMS software is an essential element to be integrated into the conceptualisation, adoption and maintenance of any curricular and instructional processes that we care to design and implement, allowing for stringent accountability criteria to be met in the provision of a general education for all students that can be justified in its own terms. Good responsive software design allows for the establishment of relationships between curriculum elements, instructional process and assessment and evaluation thereby facilitating alignment between each of them and with external standards. Moving toward outcomes-based education will help schools monitor their performance more effectively and thereby improve the quality of teaching and learning.

The use of a new generation of software tools with great transformative potential, such as those described above, may help us break the lock of at least some of the constraints that have previously inhibited us in bringing about classroom change and school improvements. Ultimately, implementation success has to be judged in terms of the achievement of student learning outcomes, as well as in improved management practices and restructured environments supportive of the notion that all students can learn, and that it is the responsibility of schools to ensure that in fact they do.

Realising this vision is likely to place heavy demands on curriculum management and require the exercise of high quality leadership (Carter, Glass and Hord, 1993). As already asserted in this paper, and developed as one of its main themes, we now have a new generation of information technology available, which, when allied to human capacities and a vision of the future that we hold, can assist the transformation of schools. The caveat is, however, that if we do not at the same time attend to the deepening of vision and ensure that instructional systems are well understood, the transformative potential of new information technology, where it counts most in schools and classrooms, is unlikely to be fully realised.

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